

NEW SPECIES OF *PSEUDODIAPTOMUS* FROM THE
INDO-PACIFIC, WITH A CLARIFICATION OF
P. AURIVILLI AND *P. MERTONI*
(CRUSTACEA: COPEPODA: CALANOIDA)

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Abstract.—*Pseudodiaptomus aurivilli*, *P. trihamatus*, and *P. bispinosus* were collected from shallow Philippine coastal waters. In addition, other Indo-Pacific species previously misidentified as *P. aurivilli* and *P. mertoni* are assigned separate status as the new species *P. compactus*, *P. bowmani*, *P. sewelli*, and *P. baylyi*. These species plus *P. incisus* are herein assigned to the *Hyalinus* species group, as they all possess a lamellar hyaline membrane on the second exopod of the male left fifth leg, and other common morphological features.

A previous study on the emergence of reef associated zooplankton from Philippine coral reefs (Walter *et al.* 1982) reported the quantitative rates of emergence of zooplankton over 24-hr cycles. This paper and papers in preparation will report on the taxonomic composition of species captured from the Philippines. The results of this study clarify some problems of synonymy in existing species, and ascribe specimens previously identified as *P. aurivilli* and *P. mertoni* to new species *P. compactus*, *P. bowmani*, *P. sewelli*, or *P. baylyi*. A fourth species, *P. bispinosus*, is described.

The family Pseudodiaptomidae is composed of two genera: *Pseudodiaptomus* Herrick, 1884, and *Archidiaptomus* Madhupratap and Haridas, 1978; the latter consists of but one species, *A. aroorus*. Sixty species have been assigned to the genus *Pseudodiaptomus* before this study. The addition of five new species brings to 47 those species known from the Indo-Pacific: *P. annandalei* Sewell, 1919; *P. andamanensis* Pillai, 1980; *P. ardjuna* Brehm, 1953; *P. aurivilli* Cleve, 1901; *P. batillipes* Brehm, 1954; *P. beieri* Brehm, 1951; *P. binghami* Sewell, 1912; *P. binghami malayalus* Wellershaus, 1969; *P. brehmi* Keifer, 1938; *P. bulbiferus* (Rose, 1957); *P. bulbosus* (Shen and Tai, 1964); *P. burckhardti* Sewell, 1932; *P. clevei* Scott, 1909; *P. colefaxi* Bayly, 1966; *P. cornutus* Nicholls, 1944; *P. daughlishi* Sewell, 1932; *P. forbesi* (Poppe and Richard, 1890); *P. galleti* (Rose, 1957); *P. heterothrix* Brehm, 1953; *P. hickmani* Sewell, 1912; *P. incisus* Shen and Lee, 1963; *P. inflatus* (Shen and Tai, 1964); *P. inopinus* Burckhardt, 1913; *P. inopinus saccupodus* (Shen and Tai, 1962); *P. jonesi* Pillai, 1970; *P. lobipes* Gurney, 1907; *P. marinus* Sato, 1913; *P. masoni* Sewell, 1932; *P. mertoni* Fruchtl, 1923; *P. nankauriensis* Roy, 1977; *P. nihonkaiensis* Hirakawa, 1983; *P. ornatus* (Rose, 1957); *P. poplesi* (Shen, 1955); *P. poppei* Stingelin, 1900; *P. salinus* (Giesbrecht, 1896); *P. serricaudatus* (T. Scott, 1894); *P. smithi* Wright, 1928; *P. spatulatus* (Shen and Tai, 1964); *P. stuhlmanni* (Poppe and Mrazek, 1895); *P. tollingeri* Sewell, 1919; *P. trihamatus* Wright, 1937; *Pseudodiaptomus* sp. (Nishida, pers. comm.).

Pseudodiaptomids enjoy worldwide distribution in shallow coastal waters and

typically remain near or on the bottom during the day and rise into the water column at dusk, and therefore should be searched for in night plankton samples. This diel migration is especially pronounced during new moon or very cloudy conditions. Members of this genus have been found from freshwater lakes and reservoirs to hypersaline conditions. In this study, specimens are strictly marine, collected over coral reef, grass flat, coral rubble, and soft-mud bottom embayments at Padre Burgos, Quezon Province, Luzon (13°53'N, 121°47'E) Philippines.

Abbreviations

A1 = first antenna	Se = outer spine
P1-P5 = first-fifth swimming legs	St = terminal spine
Pdg1-5 = pedigers 1-5	Re = exopod
Ur = urosome	Ri = endopod
Pr = prosome	B1-B2 = basipods 1-2
CR = caudal rami	Ur1-5 = urosome segments 1-5

In general, species determination in pseudodiaptomids relies on the morphology of male P5, with other body characters and female morphology secondary in importance. Males of several species of *Pseudodiaptomus* possess a hyaline membrane on the outer margin of the distal segment of the left Re of P5. Species possessing this character, herein referred to as the "Hyalinus" group, also share the following unique characters which are not repeated in the descriptions of the species: i) Female A1 with 21 segments (compared to the typical 22 segments common to all other pseudodiaptomids), as there are only 4 segments (Fig. 1A) proximal to the partly fused segments which are counted as separate segments. ii) Left and right female A1 and left male A1 lack dorsal barbed seta on antepenultimate segment, though the divided ventral plumose seta is present. iii) Male right A1 with 20 segments (Fig. 1B), left A1 with 22 segments and unlike the female there are 5 segments proximal to partly fused segments. iv) No detectable sexual dimorphism in P1-4 though a lateral row of 11 long spinules on B2 of P1 is present. v) Female Ur1 ventrally possesses 1 pair of spines (the right spine usually longer than the left) and an accompanying pair of posterior setae on each side of genital opening (Fig. 2D). Other common characteristics present but not specific to the Hyalinus group are: i) Terminal esthete of A1 without sexual dimorphism, although these esthetes vary in size and shape among the species. ii) Head and Pdg1 fused. iii) Wings of Pdg5 are large, directed posterolaterally and of similar size in females; small, directed posteriorly and of similar size in males. iv) Ur1 longest segment in females; Ur1-3 with posterodorsal spine rows that increase in size from Ur1 to Ur3. In males, Ur2-4 have posterior spine rows that completely encircle the segments and also increase in size from Ur2 to Ur4.

Females and males of the Hyalinus group possess the following P5 characters. These characters will not be repeated in the descriptions of either male or female P5. Females; P5 symmetrical. B2 with 1 large surface seta and row of fine hairs along outer margin. Re1 with 1 surface seta, row of fine hairs or spinules and plumose Se on lateral margin. Re2 small with fine hairs on proximomedial margin, produced distally into a plumose spiniform process; St plumose on medial margin, more than 2 × longer than Re2 process with a plumose auxiliary basal spine almost equal in length to Re2 process; Se short, plumose on medial margin. Males; P5

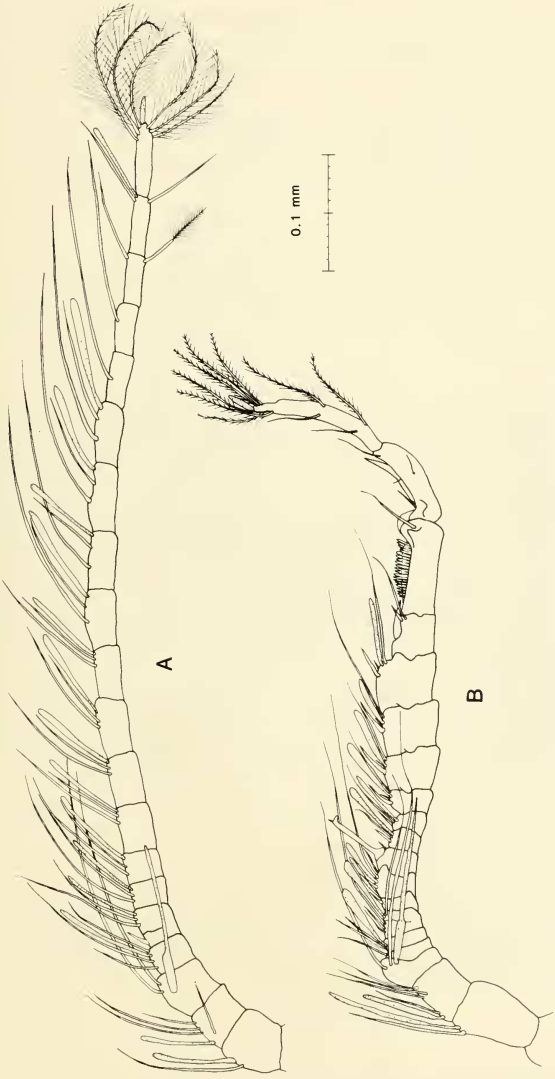


Fig. 1. *Pseudodiaptomus aurivillii* Cleve, USNM 204909; Right A1, medial view: A, Female; B, Male.

Table 1.—Comparison of morphological features between the 2 species-types of the *Hyalinus* group.

Sex	<i>aurivilli</i> -type	<i>trihamatus</i> -type
Female		
Genital boss	Very large and swollen	Small or shrunken
Ur1 ventral spines	Somewhat long and robust	Longer and slender, with the right longer
P5	Re1 about 1.2 × longer than B2	Re1 about 1.4–1.6 × longer than B2
Male		
P5 left Re2	Hyaline membrane convexly curved	Hyaline membrane incised
P5 right Re2	Se small, slender plumose	Se large and stout sometimes possessing medial spines
P5 Ri	Short and compact points	Larger and more elongated digitiform points

non-symmetrical, consisting of right leg with 2 basipods and 3 exopods, left leg with 2 basipods and 2 exopodal segments, and the following features: Posterior view, Right leg: B1 with subapical row of spinules. B2 larger than left B2, with rounded outer lateral margin and 1 large surface seta. Re2 with at least 1 small surface seta. Re3 proximally thickened, with variable basal process and seta; distally produced into spiniform, slightly curved process with plumose medial margin. Left leg: B1 with subapical row of spinules. B2 with 1 large surface seta. Re1 with 1 small surface seta and long plumose Se. Re2 with hyaline process on outer margin. Anterior view, Right leg: B1 with proximal rows of fine hairs and/or spinules. B2 spinule row along lateromedial margin continues onto surface at midlength, a Se of varying shape and a trifold Ri. Re2 ornamented with rows of spinules and hairs. Left leg: B1 with proximal row of fine hairs. B2 with spinule row at midlength.

Members of the *Hyalinus* group can further be divided into two "species-types" (Table 1) with all species in this group found in the Indo-Pacific region. Their northern range is from the Indian and South China Seas including the Philippines and Indo-Malayan region, south to the northern and eastern coasts of Australia. (* denotes specimens observed and described during present study)

"*aurivilli*-type" = (**P. aurivilli*, *P. mertoni*, **P. bowmani*, **P. compactus*).

"*trihamatus*-type" = (**P. trihamatus*, **P. sewelli*, **P. bispinosus*, *P. incisus*, **P. baylyi*).

Length of prosome and urosome were taken dorsally from anterior margin of head to posterior tip of Pdg5, and from anterior margin of Ur1 to distal tip of CR. Since tip of Pdg5 overlaps Ur, specimen total length is less than combined lengths of the Pr and Ur.

Pseudodiaptomus aurivilli Cleve

Figs. 1–2

Pseudodiaptomus aurivilli Cleve, 1901:48–50, pl. 6, figs. 11–22, pl. 7, figs. 1–2.—Thompson and Scott, 1903:248, pl. 2, figs. 24–26.—Scott, 1909:116.—Sewell,

1912:116.—1914:224–226.—Früchtl, 1924:50–52.—Marsh, 1933:30–31, pl. 15, figs. 3, 5–7.—Tanaka, 1963:12.

[?] *Pseudodiaptomus aurivilli*.—Krishnaswamy, 1953:118, 122–123, fig. 4.—Björnberg, 1963:100.

[?] *Pseudodiaptomus mertoni* Früchtl.—Sewell, 1932:241, fig. 85b, [= *P. cf. aurivilli*].—Brehm, 1934:88, 93, fig. 2.

[non] *Pseudodiaptomus cf. P. aurivilli*.—Bayly, 1966:54, 55, figs. 2d–f, 3c–d.

[non] *Pseudodiaptomus aurivilli* Cleve.—Sewell, 1932:240–241, fig. 85a.—Kasturirangan, 1963:36, figs. 31a–d, 32a–c.—Ummerkutty, 1964:48–52, pl. 2, figs. 23–24.—Wellershaus, 1969:254–256, figs. 21–22.—Pillai, 1980:248, fig. 1a–b.

Material.—Philippines: Padre Burgos, Quezon, coral reef, 3 m, 7–10 Jan 1981, 50 males, 50 females; USNM 204909, coll. by Walter and Talaue.

Sex	#	Length (mm)	\bar{x}	Pr \bar{x}	Ur \bar{x}	Pr:Ur
Female	412	1.20–1.30	1.22	0.80	0.49	1.6:1
Male	241	0.94–1.00	0.98	0.68	0.37	1.8:1

Description.—Female Pdg1 posterodorsal margin thickened. Distolateral corners of Pdg2 and 3 with small tufts of fine spinules. Pdg4 and 5 incompletely fused, with pair of fine hairs on each side of urosomal insertion. Usually with 3 pairs of black pigment spots on Pr that gradually fade in ethanol. Ur1 with proximal patch of fine hairs on lateral surfaces; genital boss swollen ventrally, with 1 pair of stout spines (Fig. 2A–D). Ur4 with pair black pigment spots that do not fade in ethanol. CR 7× longer than wide. Ur segments and CR in the proportions 28:13:13:12:34 = 100. A1 as in Fig. 1A. P5 posterior view (Fig. 2C): B1 with slightly pointed distomedial corners. B2 proximomedial corners rounded. Re1 outer medial margin lined with fine spinules. Male Pdg1 with posterodorsal margin thickened. Pdg4 and 5 incompletely fused. Pr with 3 pairs of black pigment spots as in females. Ur1 with distal swelling on right side and patch of very fine hairs at each anterolateral corner (Fig. 2E–G). Ur2 with few proximal hairs and ventral row of small spinules. Ur4 with pair of black pigment spots that do not fade in ethanol. CR 3× longer than wide. Ur segments and CR in the proportions 17:21:17:15:10:20 = 100. A1 as in Fig. 1B.

P5 posterior view (Fig. 2H): Right leg, B1 distal corner bifid, inner process reaching beyond base of Re2, outer process triangular and short. B2 with 2 small surface setae; Se large with recurved apex, medial knob and 1 seta. Re1 very short but produced into a long stout posterolateral process with proximal auxiliary spine. Re2 rectangular with plumose Se. Re3 with 2 setae. Left leg, B1 distomedial corner rounded. B2 with 2 small surface setae. Re2 with 6 setae, semi-circular with hyaline process completing ovoid shape of segment; proximal outer corner with one distally and one medially directed short plumose process. P5 anterior (Fig. 2I): Right leg, B1 with large subapical spinules. Ri forked, outer fork slightly longer and bifid. Re3 with small proximal knob. Left leg, B1 with large subapical spinules. B2 with proximal row of spinules. Re1 with patch of very fine hairs at Se base. Re2 with row of fine hairs at proximal corner.

Remarks.—Cleve's original description of *P. aurivilli* was based on an unknown number of females from the Malay archipelago. As can be seen from the figures,

females and males of the *Hyalinus* group have similar body shapes and P5 structure. Therefore, the designation of Cleve's species from the female only and the similarity among females and males within the genus set the stage for 80 years of taxonomic confusion.

Present females agree with Cleve's female in the following: i) A1 with 21 segments, if one counts partly fused segments separately, which Cleve did not, and an elongate terminal esthete. ii) P5 inner proximomedial corners of B2 rounded and Re1 is shorter than in *trihamatus*-type species. iii) Ur1 without distal marginal swellings dorsally. iv) Ur1 genital boss with two long spines. v) CR 7× longer than wide.

Differences between Cleve's drawings and present females are that the genital boss is more prominent and Pdg4 and 5 are partly fused. Cleve (1901:48) states "*Th1* and *Th2* uniting" yet all pseudodiaptomids have the first and second pedigers free; this notwithstanding, I feel that they are the same species. Thompson and Scott (1903) collected specimens of both sexes from the Indian Ocean (Sri Lanka), referred them to *P. aurivilli*, and designated a male for the species. They did not describe either sex and their drawings are uninformative.

Sewell (1912:363) found specimens of *P. aurivilli* and concluded that they "were without exception, females and agreed with Cleve's description." Sewell (1914:225-226) in support of the above, found numerous examples of both sexes, reported the head and Pdg1 fused with Pdg4 and 5 only partly fused, and that in males "the fifth pair of legs correspond exactly with the description given by Thompson and Scott." Sewell did not illustrate either sex or provide a description of the female. In a later study Sewell (1932) revised his original support of Thompson and Scott's male of *P. aurivilli*. Following Früchtl's (1924) description of *P. mertoni*, Sewell reported his males (1932, fig. 85b) as *P. mertoni*. However, differences between Sewell's figured male and that of Früchtl's include: i) Inner spine of right B1 less than half the length of B2, with absence of shorter triangular process. ii) Left B1 with pointed triangular corner and spiniform process at distomedial margin absent. iii) Se of right B2 short. iv) Re3 with large basal knob. v) Left Re2 hyaline process not drawn. Sewell's 1932 illustration (fig. 85b) does not agree completely with his 1914 statement that the male P5 exactly corresponded to Thompson and Scott's material. Unless additional specimens or original material can be reexamined the status of *P. mertoni* sensu Sewell is vague and my assignment of this species to *P. aurivilli* is tentative. The above discussion, plus my collected material, supports Thompson and Scott's designation of the *P. aurivilli* male, thereby completing the species description.

Pseudodiaptomus mertoni Früchtl

Fig. 3A

Pseudodiaptomus mertoni Früchtl, 1923:455-456, pl. 26, figs. 23-24.—1924:49-53, figs. 31-36.—Brehm, 1934:88, 93, fig. 1a-b.—Bayly, 1966:55, 56, figs. 2g-i, 3e-f.—Greenwood, 1977:66.—1982:58.

[?] *Pseudodiaptomus mertoni*.—Saraswathy, 1967:79.

[?] *Pseudodiaptomus aurivilli*.—Ummerkutty, 1964:48-52, pl. 2, figs. 23-24.

Pseudodiaptomus sp. 3.—Bayly, 1965:327.

[non] *Pseudodiaptomus mertoni*.—Sewell, 1932:241, fig. 85b.—Wellershaus, 1969:256-258, fig. 23.—Pillai, 1980:246, fig. 1c-d.

Material.—No material was available for study and descriptive purposes. The following remarks are based on information obtained from the literature and comparative species from the Philippines and India.

Remarks.—Früchtl (1924) discussed what he believed to be the correct *P. aurivilli* and *P. mertoni* species pairs from India. He associated what he thought was Thompson and Scott's male of *P. aurivilli* (Fig. 3A) with females of a different undescribed species and designated them as a new species *P. mertoni*. This then left the female of *P. aurivilli* unpaired till Sewell (1932, fig. 85a) re-associated it with a new male (see discussion under *P. sewelli*).

I am of the opinion that Früchtl did not have Thompson and Scott's male of *P. aurivilli* and that his association was incorrect based on the following: i) *P. aurivilli* male with Pd4 and 5 partly fused, completely fused in Früchtl's male. ii) P5 of Früchtl's male with elongate spiniform process on left B1 (Fig. 3A), right B1 bifid process shorter and left Re2 hyaline membrane different from illustrations of Thompson and Scott (1903) and Sewell (1932). Besides not having the male he thought he had, Früchtl's male and female association was incorrect, as the female lacks a posterodorsal spine row on Ur1 and the ventral surface of Ur1 with dense goatee of felt-like hair (1924:50) ("dichtanliegendem ziegenbartartigem Haarfilz") at genital opening. The lack of two ventral spines and posterodorsal spine row removes it from the Hyalinus group, and it therefore can not be conspecific with the male.

In addition, Früchtl divided these two species by the length of CR setae, which I believe is not an appropriate diagnostic tool for species division in this group. Früchtl's conclusions and species designation of *P. mertoni* were accepted by most later authors, including Sewell (1932).

From the above, it is evident that Früchtl's assumption that the male of Thompson and Scott's *P. aurivilli* ought to be associated not with Cleve's female, but with his appropriate female, is invalid. Only his male is representative of the new species *P. mertoni* as it differs from *P. aurivilli*, and as such holds the designation of *P. mertoni*, while the status of the female awaits collection of subsequent material and does not belong to the Hyalinus group.

Australian specimens of *P. mertoni*, both sexes collected by Bayly (1966), agree with Früchtl's *P. mertoni* males with the male-female pairs appearing conspecific, thereby completing the association of sexes. Similar material from Indian waters was referred to *P. aurivilli* by Ummerkuty (1964). I believe Ummerkuty's specimen belongs to *Pseudodiptomus* cf. *P. mertoni*, as he failed to indicate on male P5 a hyaline membrane on left Re2; right B1 distal spine is longer, and Se of right B2 is shorter than Früchtl's male.

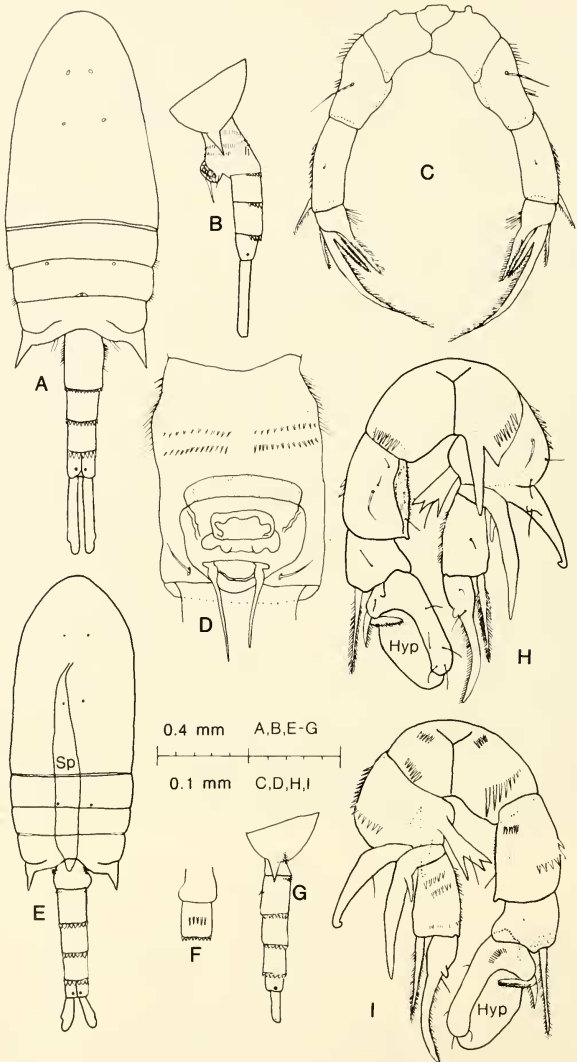
Pseudodiptomus compactus, new species

Fig. 3B-C

Pseudodiptomus aurivilli.—Kasturirangan, 1963:36, figs. 31a-d, 32a-c.

Pseudodiptomus mertoni.—Wellershaus, 1969:256-258, fig. 23.—Pillai, 1980: 246, fig. 1c-d.

Material.—The following is based on the re-examination of Wellershaus's specimen. Kasturirangan's illustration of *P. aurivilli* from the west coast of India appears to be the same species. India: Cochin Backwater, near Cochin outlet,



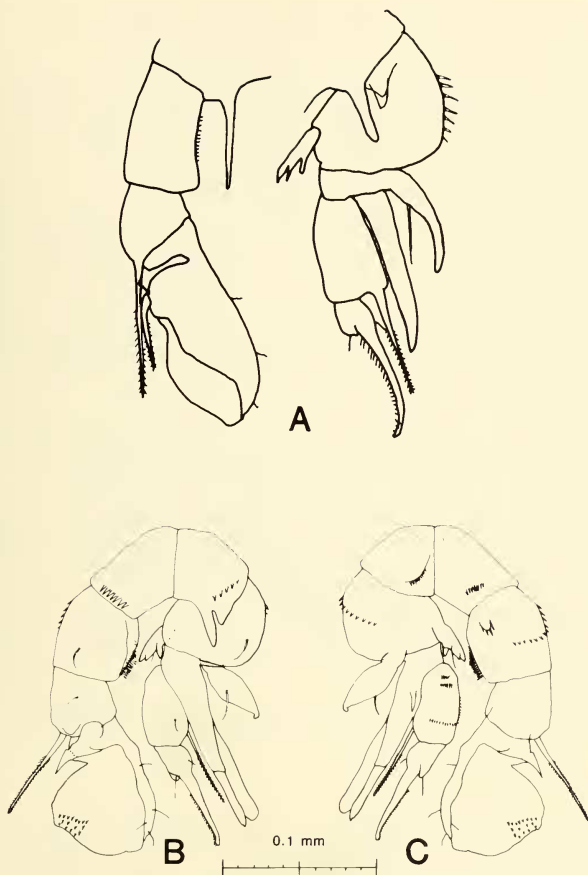


Fig. 3. A, *Pseudodiptomus mertoni* Früchtl, posterior view of male P5, redrawn from Früchtl (1923). B-C, *Pseudodiptomus compactus*, new species, holotype, adult male, Zool. Mus. Kiel, Cop. 35: B, P5 posterior view; C, P5 anterior view.

Fig. 2. *Pseudodiptomus aurivilli* Cleve, USNM 204909: A-D, Adult female; A, Dorsal view; B, Lateral view of left side of Ur; C, Posterior view of P5; D, Ventral view of genital segment. E-I, Adult male; E, Dorsal view of specimen; F, Ventral view of Ur1 and 2 showing spinules on Ur2; G, Lateral view of left side of Ur; H, P5 posterior view; I, P5 anterior view. (Hyp = Hyaline membrane; Sp = Spermatophore).

surface, 31 May 1966, Zoological Museum Kiel, 1 male dissected on a slide, Cop. 35, holotype.

Description.—Pd₄ and 5 fused in males; other details not available as specimen was crushed on slide; see Wellershaus (1969) for further description. Female Pd₄ and 5 fused, genital boss very prominent (Kasturirangan 1963, fig. 31a–b).

P5 male, posterior view (Fig. 3B): Right leg, B1 with distomedial corner bifid, inner process longer and bluntly pointed, outer process triangular. Se of B2 short, stout with recurved apex and 1 medial seta. Re1 long (reaching distal end of Re3), divided near distal tip with a straight elongate hyaline plate along posterolateral margin, giving the appearance of a spatulate Se. Re2 with long thin plumose Se. Re3 with 2 setae. Left leg, B1 distomedial corner simple. B2 medial margin lined with small spinules along groove. Re1 with shoulder-like knob at distal corner at base of Se. Re2 narrow with 4 setae along medial edge, proximal ear-shaped protrusion, stout proximolateral spine and large ovoid hyaline process with patch of fine spinules distolaterally. P5 male, anterior (Fig. 3C): Right leg, B1 with fine subapical spinules. Ri compact, longer branch bifid, with 1 seta between the 2 small blunt points. Re1 with pointed basal process. Left leg, B1 with spinule row along distal suture.

Remarks.—Wellershaus's specimen differs from Kasturirangan's in the absence of a hyaline plate on right Re1 and spinules on hyaline process of left Re2. Otherwise, these two descriptions appear the same, with this species differing from *P. mertoni* in: i) Left B1 lacks elongate distal spine. ii) Right B2 with short Se, recurved at apex. iii) Right Re1 elongate, divided near distal end with large auxiliary hyaline plate. iv) Ri more compact with distal two points only slightly separated. v) Left B2 with row of coarse spinules at inner margin. vi) Proximolateral margin of left Re2 with short spine and somewhat circular hyaline process with small spinules along outer margin. These differences warrant a separate species status from *P. mertoni*. Specimens of *P. compactus* from the Cochin Backwater were reported as *P. mertoni*, by Pillai (1980), though his text (p. 248, fig. 1a, b) should read Fig. 1c, d.

Etymology.—The name *compactus* refers to the small compact Ri of the right P5 and blunt closely aligned distal pair of points on the longer branch.

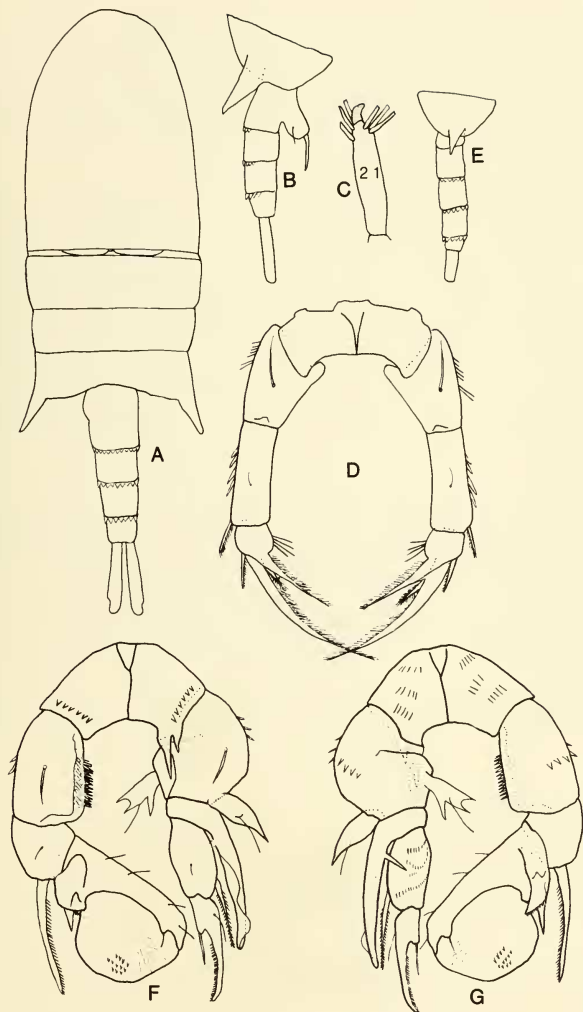
Pseudodiptomus bowmani, new species

Fig. 4

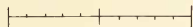
Material.—India: Cheval Parr, Gulf of Manaar, May and Oct 1955, from the Marine Zoological Society of India, identified by R. B. S. Sewell as *P. aurivilli*, 1 male, 0.98 mm, USNM 102081, holotype: 1 female, 1.24 mm, USNM 204903, allotype.

Description.—Female Pd₁ with thickened posterodorsal margin. Pd₄ and 5 fused (Fig. 4A–B). Ur1 without fine hairs, slight swelling at left anterior margin;

Fig. 4. *Pseudodiptomus bowmani*, new species, A–D, Adult female allotype, USNM 204903: A, Dorsal view; B, Lateral view of right side of Ur; C, Terminal segment of A1 showing short curved esthete; D, Posterior view of P5. E–G, Adult male holotype, USNM 102081: E, Lateral view of right side Ur; F, P5 posterior view; G, P5 anterior view.



0.4 mm A,B,E



0.1 mm C,D,F,G

genital boss extremely produced ventrally with 1 pair of stout spines. CR $6 \times$ longer than wide. Ur segments and CR in the proportions 28:15:15:11:31 = 100. Terminal esthete of A1 short and curved at apex (Fig. 4C). P5 posterior view (Fig. 4D): B1 distomedial corners slightly pointed. B2 with proximomedial corners produced into lobes. Re1 with 4 spinules along outer margin, instead of fine hairs.

Male Pdg4 and 5 fused. Ur without spinules on segments (Fig. 4E). CR $3 \times$ longer than wide. Ur segments and CR in the proportions 16:20:17:17:10:20 = 100.

P5 posterior view (Fig. 4F): Right leg, B1 with bifid medial corner; medial process elongate, pointed and twice the lateral. B2 medial margin with plate-like extension; Se short, stout and pointed at apex, with 1 seta. Re1 short produced laterally into large posterior projection with proximal process and medial undulating hyaline membrane extending from midlength to apex. Re2 with plumose Se. Re3 with 2 setae. Left leg, B2 ovoid, inner margin with small spinules along groove. Re1 with long slightly curved plumose Se. Re2 with 5 setae along medial edge, proximal ear-shaped protrusion, proximolateral spine and large circular hyaline process with distolateral cluster of fine hairs and spinules. P5 anterior (Fig. 4G): Right leg, B1 with 3 rows of fine spinules. Ri with longer branch bifid and seta inserted near base of medial proximal branch. Left leg, B1 similar to right in ornamentation. Re2 with small proximolateral spiniform process on lateral margin.

Remarks.—These specimens originally identified as *P. aurivilli* by Sewell (USNM 102081) are closely related to *P. compactus*. However, several distinct differences of male P5 indicate separate species status: i) Right B1 with acutely pointed bifid process. ii) Ri larger, more widely spaced points. iii) Se on right B2 with pointed apex not recurved. iv) Right Re1 shorter (reaching the proximal knob of Re3), distal tip simple with an undulating hyaline process (not straight). v) Re3 and Se of right Re2 shorter. vi) Left B2 groove with coarser spinules at inner margin. vii) Left Re1 Se stouter and slightly curved. viii) Left Re2 hyaline process more circular.

Etymology.—This species is named for Dr. T. E. Bowman for his help and guidance during this study.

Pseudodiptomus trihamatus Wright

Fig. 5

Pseudodiptomus trihamatus Wright, 1937:155–157, pl. 1, fig. 1.

Mazellina galleti Rose, 1957:235–240, figs. 1–3, [female only = *P. trihamatus*]

Material.—Philippines: Padre Burgos, Quezon, coral reef, 3 m, 7–10 Jan 1981, 3 males, 7 females; USNM 204907 (1 male) neotype; USNM 204908 paraneotypes, coll. by Walter and Talaue.

Sex	#	Length	\bar{x}	Pr \bar{x}	Ur \bar{x}	Pr:Ur
Female	7	1.18–1.28	1.24	0.85	0.43	2.0:1
Male	3	0.94–1.00	0.96	0.68	0.34	2.0:1

Description.—Female Pdg4 and 5 fused, with 2 pairs of fine hairs along pos-

teromedial margin; besides Pdg5 posterolateral wings there are 2 additional small spines on dorsal surface. Ur1 asymmetrical, fine hairs on anterolateral swellings; right posterodorsal margin with spine row while left margin interrupted, swollen with 2 large spines (Fig. 5A) extending posteriorly from dorsal surface. Ventrally Ur1 with weak genital boss, very long spines (Fig. 5B, C), right spine longer. Ur2 with partial spine row. CR about $6\times$ longer than wide. Ur segments and CR in the proportions $34:16:11:8:31 = 100$. Terminal esthete of A1 as in *P. aurivilli* (Fig. 1). P5 posterior view (Fig. 5D): B1 with triangular distomedial corners. B2 with 2 small surface setae, blunt wing-like extensions at proximomedial corners that protrude past segment base, distolateral corners with "shoulder." Re1 proximolateral corner with adjacent shoulder to B2, and interrupted row of fine hairs that become spinules towards distal end.

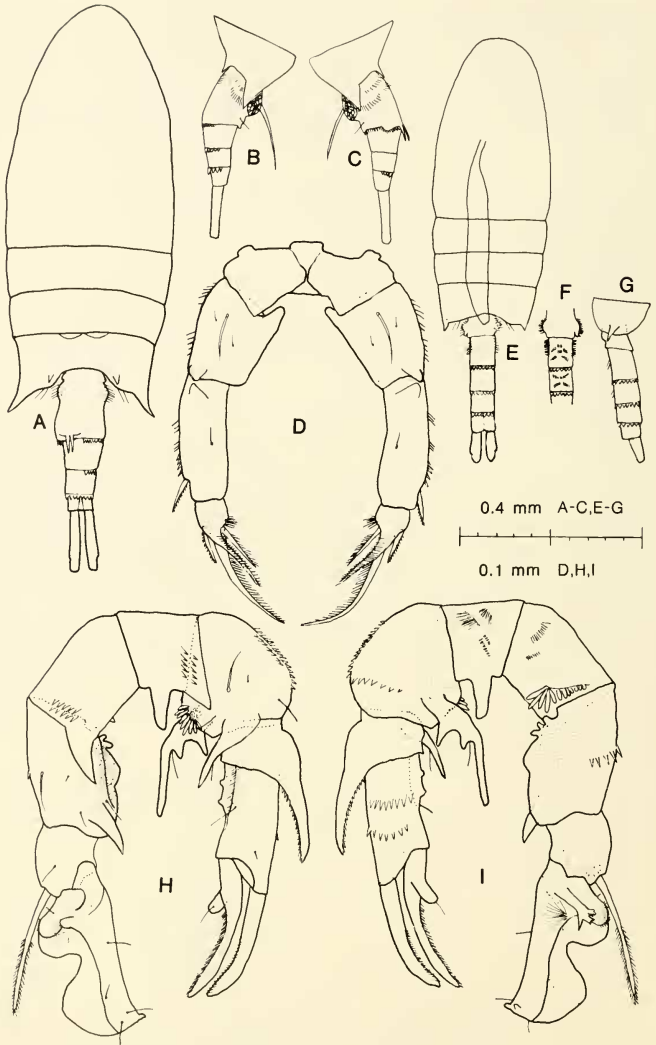
Male Pdg4 and 5 fused, Pdg5 inner margin with 2 pairs of fine hairs as in female (Fig. 5E-G). Ur1 asymmetrical, with swellings on both lateral margins covered with fine hairs. Ur2 with hairs on anterolateral margins. Ur2 and 3 with fine hairs and spinules on ventral surface that in lateral view appear as 2 rows. CR about $3\times$ longer than wide. Ur segments and CR in the proportions $16:20:18:13:13:20 = 100$. A1 as in Fig. 1B.

P5 posterior view (Fig. 5H): Right leg, B1 with elongate projection on medial margin, distal corner pointed and 2 rows of subapical spinules. B2 with 2 rows of spinules along lateral margin, 2 small surface setae, palmate cluster of blunt spinules at Ri base, and narrow distomedial curved Se with seta. Re1 large, produced distolaterally into large serrate spine. Re2 proximal inner margin with 2 knobs and patch of fine hairs along groove, 2 surface setae and elongate stout, medially plumose Se (equal in length to Re3). Re3 with ventrally elongate, basal process with seta. Left leg, B1 and B2 each with distomedial corner produced into large, acutely pointed triangular process. B1 with 2 rows of subapical spinules. B2 with 3 small surface setae, irregular projections along proximomedial inner margin. Re2 with proximal "ear-shaped" process, deeply excavated lateral lamellar hyaline membrane, 5 surface setae and small tooth projection at distomedial corner. P5 anterior (Fig. 5I): Right leg, Ri on B2 with 3 digitiform projections with seta between medial and elongate terminal. Re2 with small clump of hairs and hand-like process near proximomedial corner and very fine hairs at proximolateral margin below hyaline indentation.

Remarks.—The original description of *P. trihamatus* was based on 1 fragmented male from Philippine waters (Wright 1937) which I have been unable to locate. Wright did not know where the specimen was collected but assumed it was a freshwater species, which it is not.

The male P5 of *P. trihamatus* is very similar to *P. bispinosus*, but it differs in a number of features: Ri more elongate and digit-like, prominent curved spines on inner distal corners of left B1 and B2, palmate cluster of spines at base of Ri, and Se of right Re2 without auxiliary basal process or spines.

The female of *P. trihamatus* was originally described as a new genus and species, *Mazellina galleti* from Viet Nam (Rose 1957). Rose's diagnosis was based on a few specimens; he made no reference to the genus *Pseudodiptomus*, though all his specimens exhibit generic characteristics of pseudodiptomids. Therefore it is suggested that the three species that comprise the genus *Mazellina* (*galleti*, *ornata*, and *bulbifera*) be referred to *Pseudodiptomus*. Dr. R. Vaissière of the



Musée Océanographique in Monaco informed me that Rose's specimens were left in Algiers and are probably no longer extant.

Rose's description of female and male *P. galleti* indicated the following: i) Head and Pdg1, fused in female, not fused in male. ii) Female A1 and male right A1 with 21 segments (if following group characteristics, all males with 21 segments on right A1 should be paired with females having A1 consisting of 22 segments). iii) Male with modified barbed seta on antepenultimate segment of left A1, while absent on female A1. iv) Female with lateral spinules on B2 of P1, absent in male. These attributes suggest Rose's females and males were not conspecific.

Evidence that the *P. galleti* female and *P. trihamatus* male are conspecific follows: i) Since the male is of the Hyalinus group and similar to *P. bispinosus*, it is expected that the females also be similar. This similarity is manifested in both females possessing swellings on left posterodorsal margin of Ur1 (with an additional pair of spines on present female) and long ventral spines on Ur1. ii) Present female A1 with 21 segments (male with 20 segments), lacks modified barbed seta on antepenultimate segment, and has same type of terminal esthete as in male. iii) Both sexes have identical spinulation patterns on P1-4, with B2 possessing 11 spinules along lateral margin. iv) P5 of female same as in other members of the *trihamatus*-type group.

Pseudodiptomus sewelli, new species

Fig. 6

Pseudodiptomus aurivilli.—Sewell, 1932:240-241, fig. 85a.—Wellershaus, 1969: 254-256, figs. 21, 22.—Pillai, 1980:248, figs. 1a, b.

Material.—Sewell's material from Indian waters (Bay of Bengal) is unavailable for study. The following specimens of Wellershaus which agree with Sewell's descriptions were examined.—India: Cochin Backwater, near Cochin outlet, 7.5 m, 29 Apr 1966, 1 male, 0.94 mm, holotype: same locale surface, 4 Dec 1966, 1 female, 1.26 mm, paratype, Zoological Museum Kiel, dissected on slide, Cop. 34.

Description.—The reader is referred to Wellershaus (1969) for a description of female and male general morphology, body measurements and the female P5.

Male P5 posterior view (Fig. 6A): Right leg, B1 with small bifid process at medial margin. Se of B2 short with seta, Ri base set with fine short hairs and spinules. Re1 short, but produced into large distolateral spine, plumose on medial margin, with spiniform basal process. Re2 with 3 knobs along inner medial margin and 2 setae; Se serrate, shorter than Re3, with proximal spiniform projection and similar to Re3. Left leg, Re2 with proximal ear-shaped process, 4 setae, small projection at distomedial corner and hyaline membrane with 2 broad, shallow indentations. P5 anterior (Fig. 6B): Right leg, Ri with proximal 2 points triangular, first widest and largest, 1 fine hair between second and curved terminal point.

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 Fig. 5. *Pseudodiptomus trihamatus* Wright, A-D, Adult female paraneotypes, USNM 204908: A, Dorsal view; B, Lateral view of right side of Ur; C, Lateral view of left Ur; D, Posterior view of P5. E-I, Adult male neotype USNM 204907: E, Dorsal view; F, Ventral view of Ur1-3 showing spinule rows; G, Lateral view of left side of Ur; H, P5 posterior view; I, P5 anterior view.

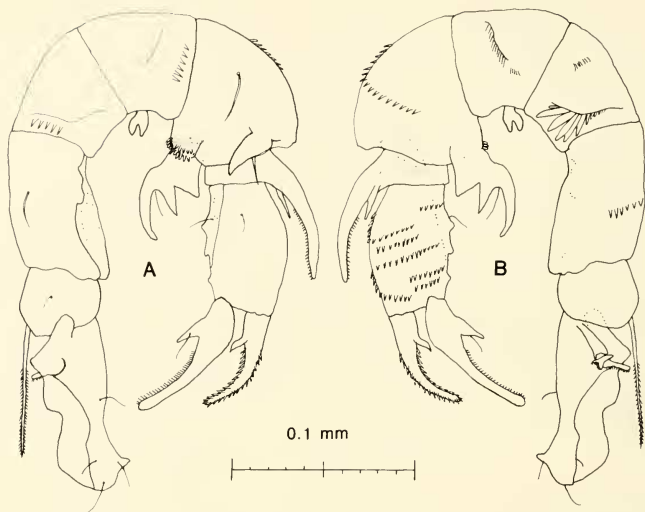


Fig. 6. *Pseudodiptomus sewelli*, new species, holotype, adult male, Zool. Mus. Kiel, Cop. 34: A, P5 posterior view; B, P5 anterior view.

Left leg, B1 with cluster of large spatulate projections along distal suture line. Re2 with unusual proximal process fringed with short hairs.

Remarks.—This species, collected from Indian waters by Wellershaus (1969) and Pillai (1980), differs from Sewell's drawings of the male P5 in that the right B1 has a small bifid process at distal margin. This notwithstanding, I consider all three reports as the species *P. sewelli*. Pillai's (1980) illustrations belong to fig. 1a, b (not 1c, d as he indicated).

The noteworthy features of the male P5 which separate it from the other species in the *trihamatus*-type group are: i) Ri proximal point large and triangular with recurved distal projection. ii) Se of right Re2 heavily serrate with 1 basal spiniform projection. iii) Hyaline process on left Re2 only slightly indented as compared to *P. bispinosus*, *P. incisus* or *P. trihamatus*.

Etymology.—*Pseudodiptomus aurivilli* sensu Sewell does not replace the male of Thompson and Scott's (1903) association and was a new species at that time. Therefore this species is named *P. sewelli* in honor of Dr. R. B. S. Sewell.

Pseudodiptomus bispinosus, new species

Fig. 7A-I

Material.—Philippines: Padre Burgos, Quezon, coral reef, 3 m, 7-10 Jan 1981, 1 male, 0.98 mm, USNM 204904, holotype; 1 female, 1.24 mm, USNM 204905,

allotype: 50 males, 100 females, USNM 204906, paratypes; coll. by Walter and Talaue.

Sex	#	Length	\bar{x}	Pr \bar{x}	Ur \bar{x}	Pr:Ur
Female	276	1.15–1.30	1.24	0.86	0.44	1.9:1
Male	69	0.94–1.00	0.98	0.66	0.34	1.9:1

Description.—Female Pdg1 with thickened posterodorsal margin. Pdg4 and 5 fused with 2 fine hairs on each side of urosomal insertion. Ur1 with fine hairs on anterolateral surface that extend dorsally; posterodorsal left margin with prominent bulge and larger spines than on right side (Fig. 7A–B). Ur1 ventral surface with small proximal knob, small genital boss and 1 pair of long spines with additional pair of small spines at genital opening. Ur2 posterodorsal margin with row of spines including 4 larger spines on left side; ventral surface with row of fine spinules. Ur3 with break in spine row, right half with larger spines. Most females have pair of dark pigment spots in Ur4 that gradually fade with time in ethanol. CR about 6 × longer than wide. Ur segments and CR in the proportions 34:14:10:10:32 = 100. Terminal esthete of A1 short (Fig. 7C). P5 posterior view (Fig. 7D): B1 with pointed distomedial corners. B2 proximomedial corners pointed. Re1 elongate (1.5 × longer than in *P. aurivilli*).

Male Pr usually with 3 pairs of pigment spots as indicated, which may fade. Pdg4 and 5 fused. Ur1 short and thickly set with fine hairs on lateral surfaces (Fig. 7E–G). Ur2 with proximal patches of fine hairs and 2 ventral rows of fine spinules. Ur3 with ventral row of fine spinules. Ur5 with pair of pigment spots that do not readily fade and present on specimens preserved in ethanol for 2 years. CR 3 × longer than wide. Ur segments and CR in the proportions 11:23:20:16:12:18 = 100. A1 as in Fig. 1B, with terminal esthete same as female.

P5 posterior view (Fig. 7H): Right leg, B1 distomedial corner bifid with 2 large pointed triangular processes, left one with medial suture. B2 with 2 small surface setae, 2 rows of lateral spinules along outer margin, patch of hair at Ri base, and naked elongate Se. Re1 with 1 seta and distolateral corner produced into attenuated large slightly curved projection, medial surface plumose. Re2 elongate, medial margin with pair of proximal knobs, patch of hair and 1 distal papilla, 2 surface setae, and lateral margin with fine hairs; Se serrate and equal in length to Re3, with 2 setae and 2 medial spines, one inserted in front of other. Re3 with large proximal hook-like knob and 2 setae. Left leg, B1 with pointed distal corner, medial protuberance with lengthwise suture line. B2 rectangular with raised posterior surface, 1 large distal and 2 small proximal knobs, patch of hairs at midlength and 1 proximal seta. Re2 large with deeply excavated hyaline process, 5 setae and distomedial corner with small triangular projection. P5 anterior (Fig. 7I): Right leg, B2 with Ri terminating in 3 points of equal length. Re1 with pointed distal spine. Left leg, B1 with cluster of finger-like spines along suture line. Re2 with hand-like process arising from proximal inner corner and row of diverging fine hairs.

Remarks.—This species is most similar to *P. incisus* Shen and Lee, 1963, from China (Fig. 7J–K). Dr. Chen Qing-chao, Academia Sinica, wrote that specimens

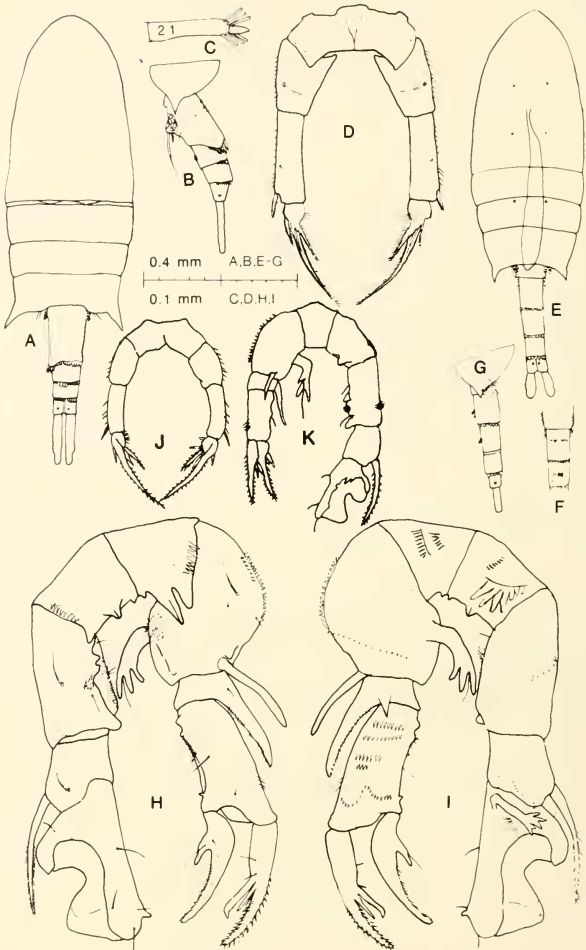


Fig. 7. *Pseudodiaptomus bispinosus*, new species. A-D, Adult female allotype, USNM 204905: A, Dorsal view; B, Lateral view of left side of Ur; C, Terminal segment of A1 showing short esthete; D, P5 posterior view. E-I, Adult male holotype, USNM 204904: E, Dorsal view; F, Ventral view of Ur1-3 showing spinule rows; G, Lateral view of left side of Ur; H, P5 posterior view; I, P5 anterior view. J-K, *Pseudodiaptomus incisus* Shen and Lee, J, Female P5 posterior view; K, Male P5 anterior view. Redrawn from Shen and Lee (1963).

of *P. incisus* are no longer extant. Based on their drawings (p. 579, figs. 15–19), the present species differs from *P. incisus* as follows: i) Left B1 with spatulate cluster. ii) Left Re2 with distolateral projection on inner medial margin and hand-like process at proximal corner. iii) Right B1 with bifid distomedial corner. iv) Se of B2 slightly longer. v) Right Re1 with larger plumose spine and auxiliary basal spine. vi) Right Re2 heavily ornamented with spinules and wider at distal end. vii) Female Ur1 with left posterodorsal margin swollen and abnormal spine rows on Ur1–3. viii) Genital boss with 2 pairs of ventral spines. ix) Female P5 with pointed proximomedial corners on B2. x) Pdg1 and head fused, not partly fused as indicated by Shen and Lee.

Females of *P. bispinosus* are distinguished from those of *P. trihamatus* by the absence of two large distal spines at swollen left posterodorsal margin of Ur1; males lack the large distal spines on left B1 and B2 of P5, the Ri is not as elongate in *P. trihamatus*, and the Se of right Re2 possess auxiliary medial spines, absent in *P. trihamatus*. Males of *P. sewelli* differ from *P. bispinosus* in that the Ri of P5 with widely spaced triangular points, Se on right Re2 with only one spine, while left Re2 lacks the deeply indented hyaline process.

Etymology.—The name *bispinosus* refers to the two medial spines present on the Se of right Re2 on male P5.

Pseudodiptomus baylyi, new species

Fig. 8A–J

Pseudodiptomus cf. *P. aurivilli*.—Bayly, 1966:54, 55, figs. 2d–f, 3c, d.

Pseudodiptomus aurivilli.—Greenwood, 1977:64–65.

Pseudodiptomus sp. 2.—Bayly, 1965:325, 327.

Material.—Australia: East Point, Darwin, surface, intertidal substrate and algal washings, 22 Aug 1982, 1 male, 0.94 mm, USNM 210669, holotype (P5 male on slide); 1 female, 0.17 mm, USNM 210670, allotype (P5 female on slide); coll. by J. L. Barnard.

Sex	#	Length	\bar{x}	Pr \bar{x}	Ur \bar{x}	Pr:Ur
Female	1	1.17	1.17	0.81	0.45	1.8:1
Male	1	0.94	0.94	0.62	0.34	1.8:1

Description.—This species is the same as *P. aurivilli* sensu Bayly (1966). Female Pdg4 and 5 fused (Fig. 8A), with additional pair of small dorsal spines and pair of fine hairs along distomedial margin. Ur1 with anterolateral patches of spinules and hairs; both lateral surfaces with small posteroventral protrusions (Fig. 8B–C) and long pair of ventral spines at genital boss. CR about 6 × longer than wide. Ur segments and CR in the proportions 30:14:14:12:30 = 100. Terminal esthete of A1 elongate (Fig. 8D). P5 posterior view (Fig. 8E): B1 with triangular distomedial corners. B2 proximomedial corners rounded and extend past medial margin.

Male Pdg4 and 5 fused (Fig. 8F). Ur1 short and naked. Ur2 with anterolateral patches of fine hairs and spinules that extend dorsally (Fig. 8G–H). Ur2–3 with

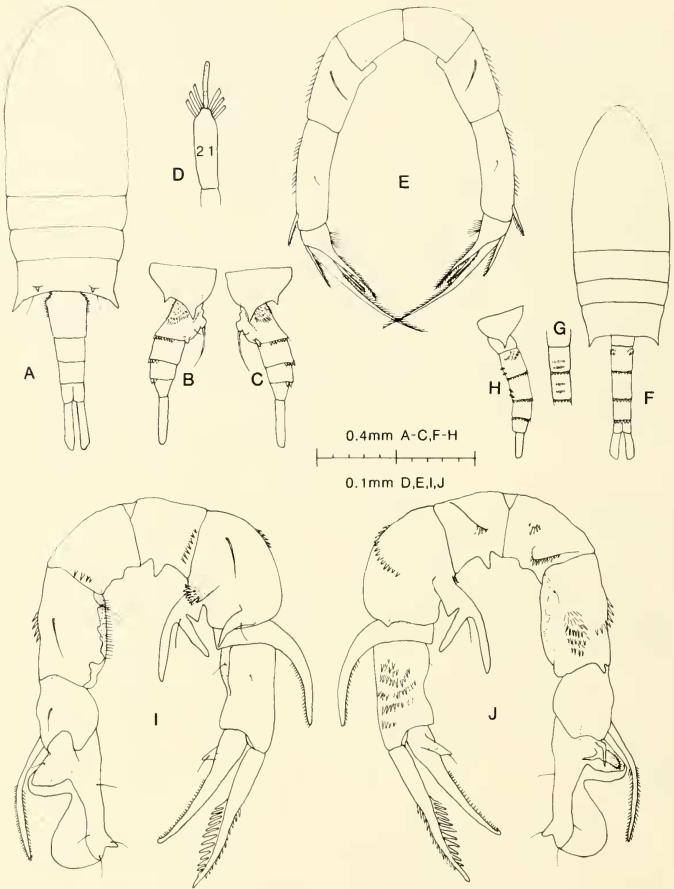


Fig. 8. *Pseudodiptomus baylyi*, new species. A-E, Adult female allotype, USNM 210670: A, Dorsal view; B, Lateral view of right side of Ur; C, Lateral view of left side of Ur; D, Terminal segment of A1 showing elongate esthete; E, P5 posterior view. F-J, Adult male holotype, USNM 210669: F, Dorsal view; G, Ventral view of Ur1-3 showing spinule rows; H, Lateral view of left side of Ur; I, P5 posterior view; J, P5 anterior view.

ventral rows of fine spinules. CR $3\times$ longer than wide. Ur segments and CR in the proportions 13:20:22:15:8:22 = 100.

P5 posterior view (Fig. 8I): Right leg, B1 medial margin with triangular projection. B2 with short curved Se bearing medial seta and spinules at Ri base. Re1 distolateral corner produced into attenuated large slightly curved projection, medially plumose. Re2 with 2 setae, proximomedial margin lined with fine hairs; Se heavily serrate on distomedial margin, distolateral margin lightly serrate. Re3 large pointed proximal process with distal seta. Left leg, B1 with small medial projection. B2 with raised posterior surface irregular in shape, 1 seta and fine hairs along medial margin. Re2 with 5 surface setae, proximal ear-shaped process, distomedial projection and large deeply excavated hyaline process. P5 anterior (Fig. 8J): Right leg, Ri of B2 trifold, though appears bifid, with small triangular proximal projection, outer branch slightly longer than inner, with 1 seta between branches. Left leg, B1 distomedial corner with raised surface bearing small spinules. B2 with 1 seta and surface spinule-hair patch. Re2 with proximal spine and Y-shaped process; lateral fork rounded and covered with fine hairs, medial fork truncate and pointed.

Remarks.—Bayly's (1966) specimens belong to the *trihamatus* group not to that containing *P. aurivilli* for the following reasons: Left Re2 hyaline membrane incised, right Re2 with large stout Se, and large Ri with prominent points. Although *P. baylyi* possesses P5 characters of both *P. trihamatus* and *P. sewelli*, it can be distinguished from the latter by: i) Absence of finger-like spine cluster on anterior surface of left B1. ii) Inner margin of right Re2 lacks irregular medial margin of *P. sewelli*. iii) Se of right Re2 heavily serrate and lacks basal spine. iv) Ri appears bifid in this species while trifold in *P. sewelli* and all other members of the *Hyalinus* group. v) Hyaline process on left Re2 deeply excavated. *Pseudodiptomus baylyi* differs from *P. trihamatus* in Ri structure, possesses smaller medial projection on right B1, Se of right Re2 serrate and simple, and finger-like spine cluster of left B1 and distomedial spines of left B1 and B2 lacking on the former.

Bayly (1966) reported distinguishing this species from mixed collections with *P. colefaxi* and *P. mertonii* by the second CR setae which are longer and bent outwards at an angle of 90 degrees. This character, however, may be an artifact of preservation, as it was not observed in present female or any females of the *Hyalinus* group.

Etymology.—This species is named for Dr. I. A. E. Bayly, well-known for his work on Australian calanoids, who first reported this species.

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